University of Saskatchewan

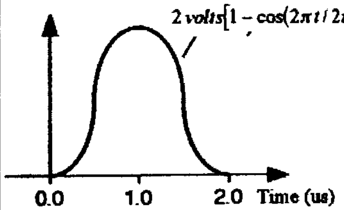
EE 325 Communication Systems I

Quiz #2 - Mar. 12/2001

Time: 30 minutes Permitted:- text, printed notes, student's own hand-written materials

*1 A junior engineer has been tasked by the design team leader to develop a circuit to produce "raised cosine pulses" for the modulator in a 500 kb/s radio data system. The pulses are required to have 2 volt peak amplitude and a positive pulse is required to transmit a logic one and a negative pulse is required to transmit a logic zero.

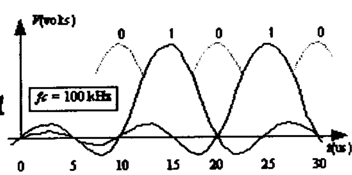
The engineer, a recent graduate with good digital skills, proposes a design using 16 bit shift registers and weighted resistors to synthesize the waveform *shown below*. One shift register is used to generate positive pulses, another is used to generate negative pulses. The engineer understands the benefit of "raised cosine" transmission and the Nyquist criteria for zero intersymbol interference, however, the theory has not been correctly applied. Identify three errors in the proposed design. (3 points)



① The illustrated waveform has 4 volt peak instead of the required 2 volt peak. Peak occurs when $(2\pi t/2us) = \pi$

② The proposed pulse is too brief and will require more transmission bandwidth than the correct pulse. For 500 kb/s symbols need to be sent at 2us intervals. For the waveform shown, pulses could be spaced at intervals of 1 us without intersymbol interference

③ The junior engineer forgot that "raised cosine" describes the frequency domain response NOT the time domain. Time domain response should be modified $\frac{\sin \pi F t}{\pi F t}$ function where F/2 is the cut-off frequency of the low-pass filter



*2 a) Pseudo-random (PN) gene... aspect of the pseudo-random... point)

If the transmis... power, then the... prior to the thre... on the run len... the pseudo-ran...

b) Consider a single pulse with amplitude + 3 volts and duration 10 us. Determine the normalized energy spectral density at frequencies near 1 kHz. (one point)

$x(t) \overset{\mathcal{F}}{\Longrightarrow} X(f) = h\tau \frac{\sin \pi f \tau}{\pi f \tau}$ note: $\frac{\sin \pi f \tau}{\pi f \tau} \simeq 1.0$ since $\tau = 10us$, $f = 1kHz$

$X(f) \simeq h\tau = 3\times10^{-5}\,V\cdot s = 30\,uV/Hz$

$E(f) = X(f)^2 = 9\times10^{-10}\,V^2\cdot s^2 = 0.9\,nW\cdot s/Hz = \boxed{0.9\,nJ/Hz}$

c) Consider a truly random NRZ data sequence at 100 kb/s with amplitude ± 3 volts. Determine the normalized power spectral density at frequencies near 1 kHz. (one point)

$S(f) = \frac{E(f)}{\tau} = \frac{9\times10^{-10}\,W\cdot s/Hz}{10^{-5}\,s} = 9\times10^{-5}\,W/Hz = \boxed{90\,uW/Hz}$

→ Note that this is PSD on a "double sided" frequency scale −∞ to +∞

d) The truly random NRZ data sequence is transmitted on a telephone line at 100 kb/s and amplitude ± 3 volts and a telephone handset is connected to the circuit by error. Assuming that the voltage levels are not changed by the handset and assuming that the handset responds only to frequencies in the range 300 – 3300 Hz, determine the effective rms voltage seen by the handset. (one point)

$P = 2\int_{300}^{3300} S(f)\,df = 2(90\,uW/Hz)(3000\,Hz) = 0.54\,W$

$V_{rms} = \sqrt{P} = \sqrt{0.54} = \boxed{0.735\ \text{Volts}}$

*3 a) What percentage of transmission capacity is allocated to framing bits and other overhead bits in the following (two points)

i. DS1 transmission carrying 24 voice channels.
ii. DS1-C transmission carrying 48 voice channels
iii. Not Marked – Question had an error!
iv. SONET STS-1 carrying one SPE

i) DS1 overhead = $\frac{1544 \text{ kb/s} - 24(64 \text{ kb/s})}{1544 \text{ kb/s}} = 0.52\%$

ii) DS1-C overhead = $24/1272 \left(\frac{\text{overhead bits/frame}}{\text{bits/frame}}\right) = 1.89\%$

DS1-C total overhead = $\frac{3{,}152 - 48(64 \text{ kb/s})}{3{,}152 \text{ kb/s}} = 2.5\%$

iv) STS-1 overhead = $\frac{810 \text{ bytes} - 783 \text{ bytes}}{810 \text{ bytes}} = 3.33\%$

*3 b) Linear PCM is used for compact disk (CD) recording while companded PCM is used in commercial telephony systems and adaptive coding is used for cellular telephones. (one point)

i. What is the advantage of companded PCM (CPCM) over linear PCM (LPCM) when used for voice transmission.
ii. How does adaptive quantization differ from companding.

i) CPCM has better SNR (quality) at smaller signal levels and slightly worse SNR than LPCM at higher signal levels. CPCM has more uniform SNR over a wide range of signal amplitudes which gives consistently good quality.

ii) Adaptive quantization uses a linear quantizer where the bin size is increased or decreased based on the recent history of the input signal. The step sizes in CPCM do not change with time (time-invariant)

4/11/01 11:41 AM

Student Number ___ Student Name: ___

University of Saskatchewan

EE 325 Communication Systems I

Quiz #3 – 6 April / 2001

1 0.9
2 2.7
3 1.0
4 0.8
5 1.2

All questions have equal value

Time: 30 minutes - Use the space below each question for your answer.

Permitted:- text, printed notes, student's own hand-written materials

6.6/10

*1. Each commercial broadcast standard has specific advantages. (two points)

a) what is the advantage of DSB-TC as used in the AM radio standard ?
b) what are the advantages/disadvantages of FM relative to AM ?
c) what is the advantage of VSB transmission for television ?
d) Is a carrier transmitted with the television VSB signal ? Explain why.

0.5 a) low cost envelope or diode detector can be used reduced cost of receivers

Ø b) ~~[illegible]~~ Inexpensive receivers, ~~[illegible]~~ no need for accurate carrier

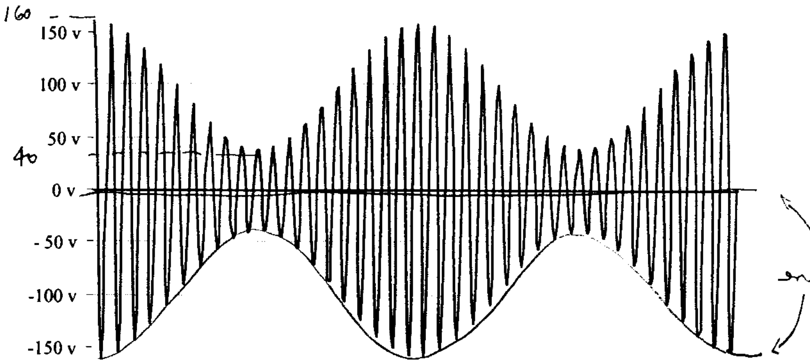
0.2 c) relatively easy signals to generate and have only a slightly greater bandwidth than SSB signals
Advantage is reduced bandwidth when compared with DSB transmission.

0.2 d) Yes, the vestige of the lower sideband is attenuated starting ~~[illegible]~~ below the carrier, the associated television sound signal, which frequency modulates a carrier, is added to VSB picture prior to broadcast

0.9

9 √

*2. In the AM-DSB-TC waveform below, the carrier frequency is 20 kHz. (4 points)
   a) what is the frequency of the sinusoidal modulation and what is the modulation index ?
   b) what is the normalized power in the i) carrier, ii) the USB and iii) the LSB?
   c) Assume that the USB component is removed and the amplitude of the LSB is doubled. This results in SSB with carrier. Sketch the resulting envelope of this modulated signal as an overlay on the waveform illustrated below.



$f_c = 20$ kHz

0.6

a) $s(t) = (1 + 0.5\cos \Omega t)(100V \cos 2\pi (20kHz) t)$ √

$\boxed{\mu = 0.5}$

1.7

b) i) $P = \frac{V_c^2}{2} = \frac{(100V)^2}{2} = \boxed{5\ kW}$ √

1

ii) $\frac{\mu^2 A_c^2}{8} = P_{USB} = P_{LSB} = \frac{(0.5 \cdot 100)^2}{8} = \boxed{312.5\ W}$ OK

iii) $= \boxed{312.5\ W}$ OK.

c)

ϕ

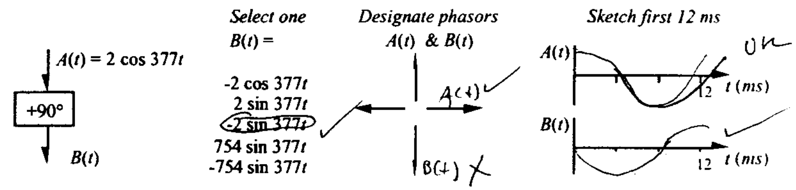
*3. A television receiver uses the superheterodyne principle with video intermediate frequency (IF) at 43.75 MHz. If the receiver is tuned to Channel 4 (with RF carrier at 67.25 MHz), what is the local oscillator(LO) frequency ? (one point)

$f_{LO} = f_{RF} + f_{IF} = 67.25\ MHz + 43.75\ MHz = \boxed{111\ MHz}$ √

1.0

*4. Quadrature sinusoidal carriers are used in QAM and in the generation of narrowband phase modulation. Complete the following three-part question on phasor notation at 60 Hz. (one point)

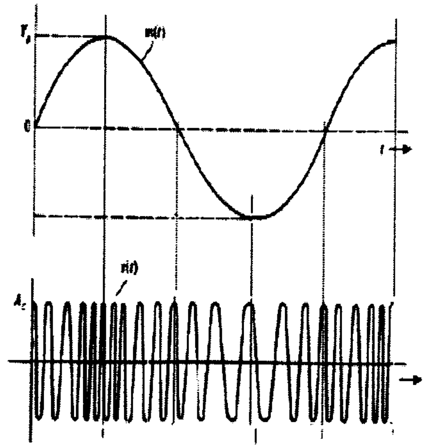
0.8



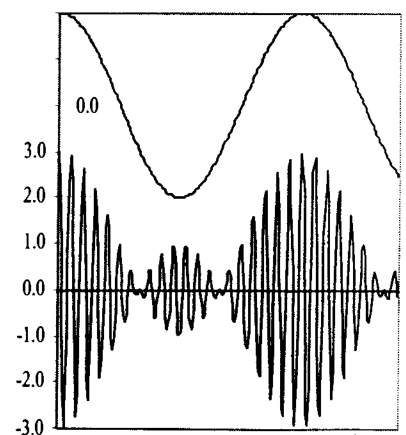
*5. Identify the following two modulated waveforms from the following choices: AM-DSB-TC, AM-DSB-SC, SSB-TC, SSB-SC, VSB-TC, VSB-SC, QAM, PM, or FM. If appropriate for your choice, estimate the modulation index. (two points)

1.2

~~AM~~ ⇒



$\beta = ?$



AM-DSB-TC √

$\mu = 2$ √

END